

Patent - Amendment After Final

Expedited Handling Requested

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application: Howell et al.

Serial No.: 09/772,949

Filed: 01/31/2001

Title: COPPER PAD STRUCTURE

Today's Date: September 10, 2002

Group Art Unit: 2814

Examiner: Graybill, David E.

FAX: 703-872-9318

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AMENDMENT AFTER FINAL UNDER 37 C.F.R. 1.116

SEP 10 2002

To the Assistant Commissioner of Patents
Washington, D.C. 20231

TECHNOLOGY CENTER 2800

Dear Sir:

In response to the Final Office Action of July 11, 2002, in which all of pending claims 16-28 stand rejected, kindly amend the subject U.S. patent application as follows. The Patent Office is hereby authorized to charge applicants' Deposit Account 09-0456 such fees as may be due for the filing of this response. Applicants do not believe that any such fee is due.

CERTIFICATE OF MAILING

I hereby certify that, on the date shown below, this correspondence is being:

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Maryann Luvisi
Name
Maryann Luvisi
Signature

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In the Claims:

Cancel claims 16-22.

23. (Amended) A method of forming a metallurgical structure, comprising:

forming a first layer of copper on a substrate;

forming a passivation structure on said first layer of copper, with a via exposing a portion of said first layer of copper;

forming a barrier layer on said passivation structure;

forming a second layer of copper on said barrier layer; and

forming a conductive structure that includes tin diffusing from said conductive structure, said second layer of copper having a thickness sufficient to substantially consume said tin diffusing from said conductive structure, and to adhere to said conductive structure.

Cancel claim 25.

27. (Amended) The method of claim 24, wherein said barrier layer is selected from the group consisting of Ti, TiN, Ta, TaN, and combinations thereof.

Please add the following new claims 29-32:

29. A method of forming a metallurgical structure, comprising the steps of:

forming an integrated circuit substrate having a final copper interconnect layer on an upper surface thereof;

forming a passivation structure on the upper surface, forming a via to expose a portion of the copper interconnect layer;

filling said via with a first barrier layer on said exposed portion of the copper interconnect layer, a second copper layer, a second barrier layer, and a third copper layer, such that said third copper layer is co-planar with said passivation structure; and

forming a tin-containing solder ball on said third copper layer, said second and third

copper layers having a combined thickness sufficient to prevent tin from said solder ball from penetrating into said copper interconnect layer.

30. The method of claim 29, wherein said barrier layer is selected from the group consisting of Ti, TiN, Ta, TaN, and combinations thereof.

31. The method of claim 29, wherein said tin-containing solder ball comprises a combination of lead and tin wherein tin is a majority component.

32. The method of 31, wherein said solder ball is approximately 63% tin and 37% lead.

Remarks

Applicants respectfully request that this amendment be entered, and that their subject U.S. Patent application be passed to issuance in view thereof. The foregoing amendments are further indicated in blackline form in Exhibit A, "VERSION WITH MARKINGS TO SHOW CHANGES MADE."

As a preliminary matter, the Applicants note that the Examiner has not indicated whether or not he has accepted the proposed drawing correction filed with Applicants' previous response. Applicants respectfully request that the Examiner so indicate his acceptance of the proposed correction.

In the Office Action, all of pending claims stand rejected as being anticipated by, or obvious in view of, U.S. Patent 5,290,732 ("Kumar"). In response, Applicants respectfully submit that the Kumar reference neither teaches nor suggests the structure as recited in these claims presented herein. Specifically, Applicants have cancelled claims 16-22, have amended independent claim 23 to address the 112 issues raised by the Examiner, and have added a new independent claim 29 and dependent claims 30-32.

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With reference first to claim 23, Applicants respectfully submit that the structure in Kumar does not teach or suggest the recited invention. In particular, note that in claim 23, the second copper layer is recited as being thick enough to substantially consume diffusion material from the overlaying conductor. The Examiner suggests that this would be an inherent property of the material 40 in Kumar. However, Applicants respectfully disagree, for several reasons. Note first that the material 40 in Kumar is taught as being thin, in order to maximize deposition throughput. That is because (as shown in Fig. 7) the material 40 is deposited using a focused ionized metal cluster beam deposition. As discussed at Col. 5, lines 45-52 of Kumar:

“...However, the first metallic bumps 40 are deposited in a thin form in order to speed up the fabrication of bumps. That is, the first metallic bumps 40, for example only, may be 500 angstroms thick of gold which are formed as in Fig. 3 by depositing the bumps 40 by a focused cluster beam. Because of the thinness of the first metallic bumps 40, they can be quickly fabricated over all of the pads 14a.”

Cluster beam tools typically have low throughput. The point of Kumar's teachings is to address this problem by using the tool to make a thin deposition. Applicants respectfully submit that such language would tend to teach away, rather than toward, the invention. The emphasis of these teachings is the deposition of a thin bump layer, not on depositing a layer thick enough to prevent penetration of materials from the solder.

Kumar is not concerned with the issue of material penetrating from the solder for a simple reason - the combination of materials used in Kumar would not have this problem. As discussed by Applicants at pages 2-3 of their specification, tin diffusing from solder does not react significantly with aluminum; it does with copper. In Kumar the pad 14 is made out of aluminum. Thus, there is no need for the metal 40 to be designed so as to prevent tin penetration into aluminum 14, since aluminum is not nearly as reactive as copper. Moreover, even if a person of ordinary skill in the art were motivated to replace the aluminum pad 14 in Kumar with copper, the thin material 40 would not be sufficient to prevent the formation of tin-copper intermetallics. Both pending independent claims 23 and 29 specify that it is tin that is the diffusion material in question; and

that the upper copper layer (or uppermost copper layers, as recited in claim 29) substantially consumes the tin before it can penetrate into the lower copper layer. Accordingly, Applicants respectfully submit that the rejections of record to claim 23 (and the pending claims dependent thereon) have been traversed.

Claim 27 has been amended to address the 112 issue raised by the examiner.

New independent claim 29 further specifies that the via is filled with two copper layers and two diffusion barriers, which further enhances the intermetallic-prevention features of the present invention. New dependent claims 31 and 32 are directed to specific compositions of the solder ball that give rise to the intermetallic problem addressed by the invention; support for these recitations can be found at page 4 of the present specification. None of these claimed features are taught or suggested by any of the prior art of record. Applicants respectfully submit that their newly submitted claims 29-32 are thus allowable.

Applicants respectfully request entry of the present Amendment and passage of their subject application to issuance in view thereof. Should the Examiner have any comments, questions, or suggestions, please do not hesitate to contact the undersigned attorney at the telephone number and/or email address set forth below.

Respectfully submitted,
For: Howell et al.

By: 

William D. Sabo
Reg. No. 27,465
Telephone: (802) 769-9454
Facsimile (802) 769-8938
Email: wsabo@us.ibm.com

IBM Corporation, IPLaw Dept. 972E
1000 River Street
Essex Junction, VT 05452

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